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LABORATORY SYSTEM FOR ALPHA PARTICLE SPECTROSCOPY

by

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Research report

LABORATORY SYSTEM FOR ALPHA PARTICLE SPECTROSCOPY

ABSTRACT

An automated alpha particle spectroscopy system has been designed and fabricated. It consists of two major components, the automatic sample changer and the controller/data acquisition unit. It is capable of unattended analysis of ten samples for up to 65,000 seconds per sample.

RÉSUMÉ

On a conçu et fabriqué un système automatique de spectroscopie de particules alpha. Il comprend deux composants, le chargeur automatique des échantillons et l'unité d'acquisition des données. Il est capable d'effectuer l'analyse sans surveillance de dix échantillons durant un maximum de 65,000 secondes par échantillon.

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A. INTRODUCTION

In July 1986, a contract was awarded to Monenco Analytical Laboratories of Calgary by Supply and Services Canada on behalf of the Atomic Energy Control Board. According to the terms of the contract, Monenco Analytical Laboratories was to upgrade the manual alpha spectroscopy system in use at the Atomic Energy Control Board's Ottawa laboratory to an automatic system. This involved the addition of an automatic sample changer and a controller/data acquisition unit. The design, construction and testing of the automatic sample changer, and the development of the controller/data acquisition unit are now completed. This report, which documents the testing and operation of the autochanger and controller/data acquisition unit, forms part of the deliverables under this contract.

B. AUTOMATED ALPHA PARTICLE SPECTROSCOPY SYSTEM

This system is schematically shown in Figure 1. All components identified by an asterisk (*) are to be supplied by the Atomic Energy Control Board.

1. Automatic Sample Changer

The automatic sample changer consists of two chambers. The upper chamber contains the motor and electronics. The lower chamber contains the alpha particle detector, the sample changing mechanism, the sample housing, and the sample receiver. The lower chamber is a vacuum chamber which can be evacuated using a vacuum pump. Figures 2, 3 and 4 show the front, right and top views of the assembly, respectively.

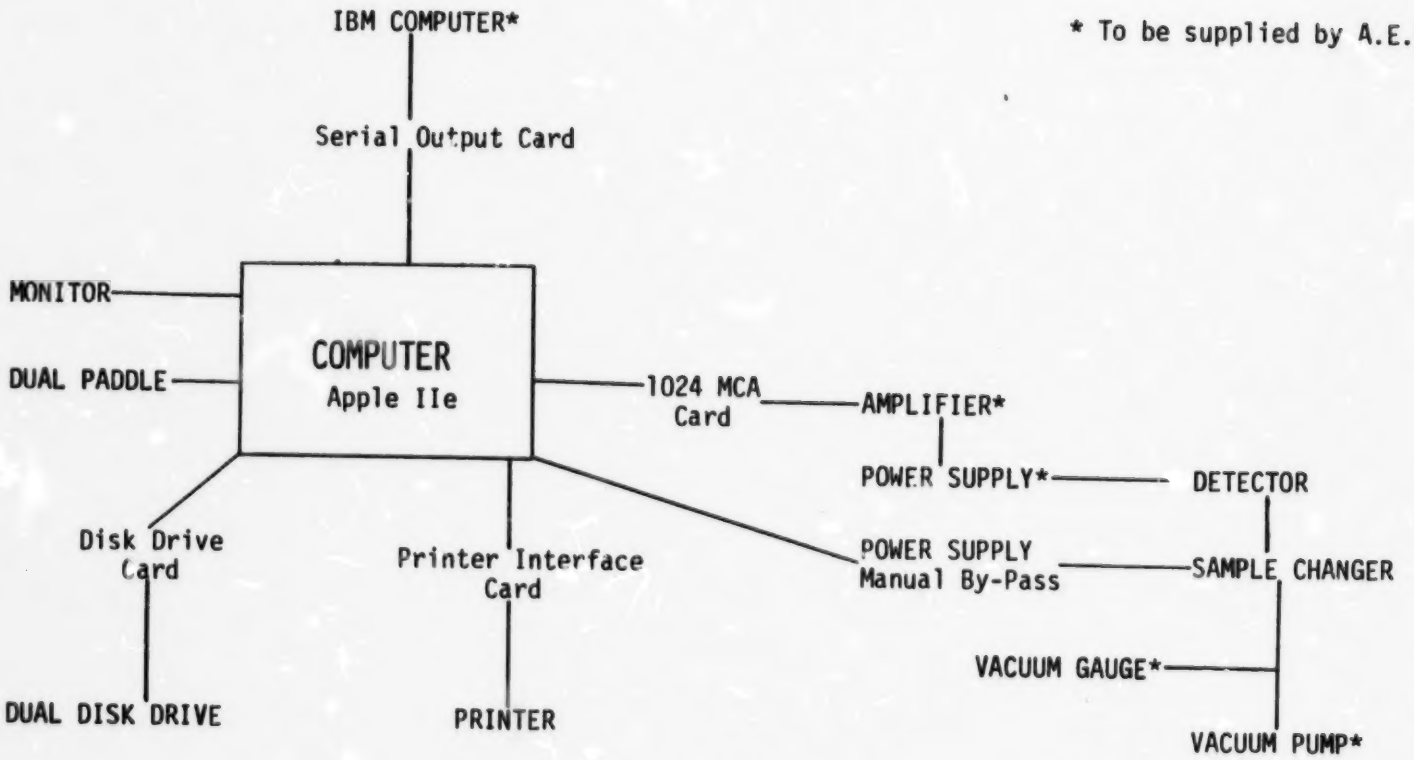


FIGURE 1 - AUTOMATED ALPHA PARTICLE SPECTROSCOPE SYSTEM

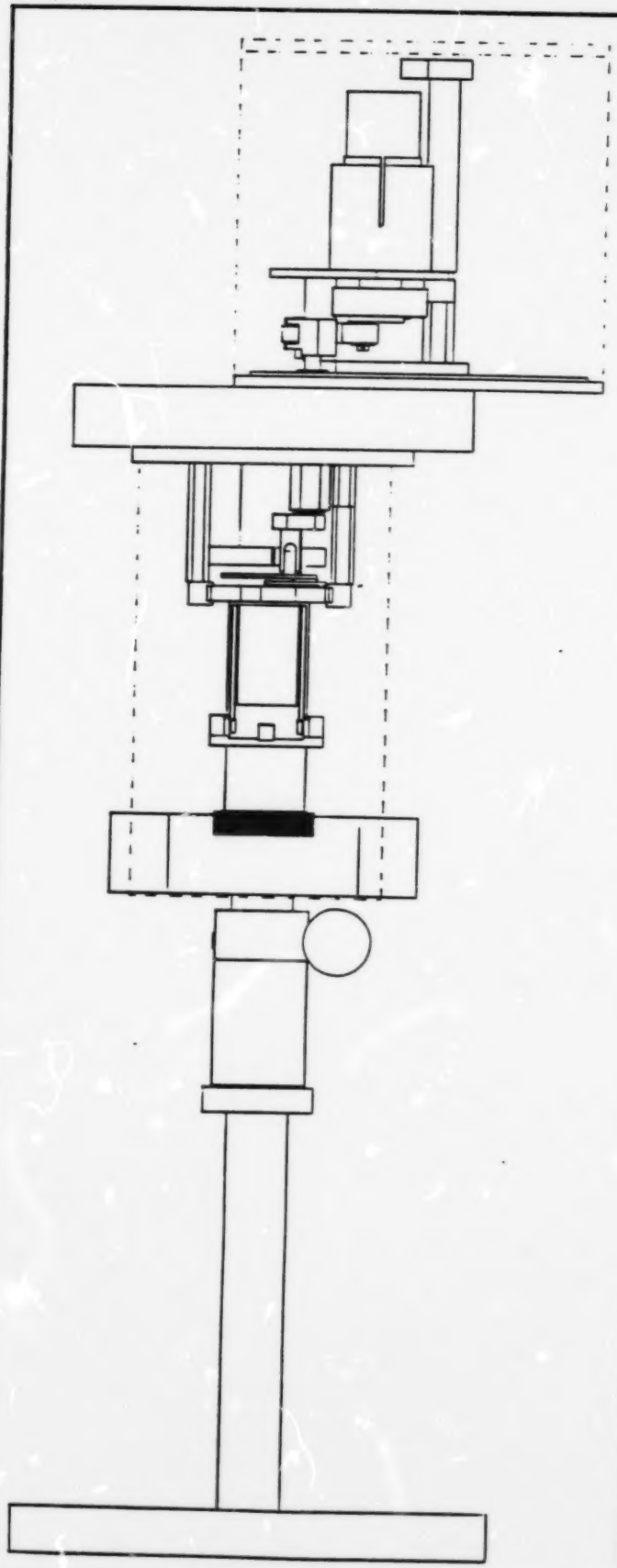


FIGURE 2

UNIVERSITY OF CALGARY DEPARTMENT OF PHYSICS		
Sample Changer Mk.I – assembly		
DR. BY: *K. Szkaradzinski*		VIEW: Front
February 3, 1987	SCALE: 1:2	NO. SC-100a

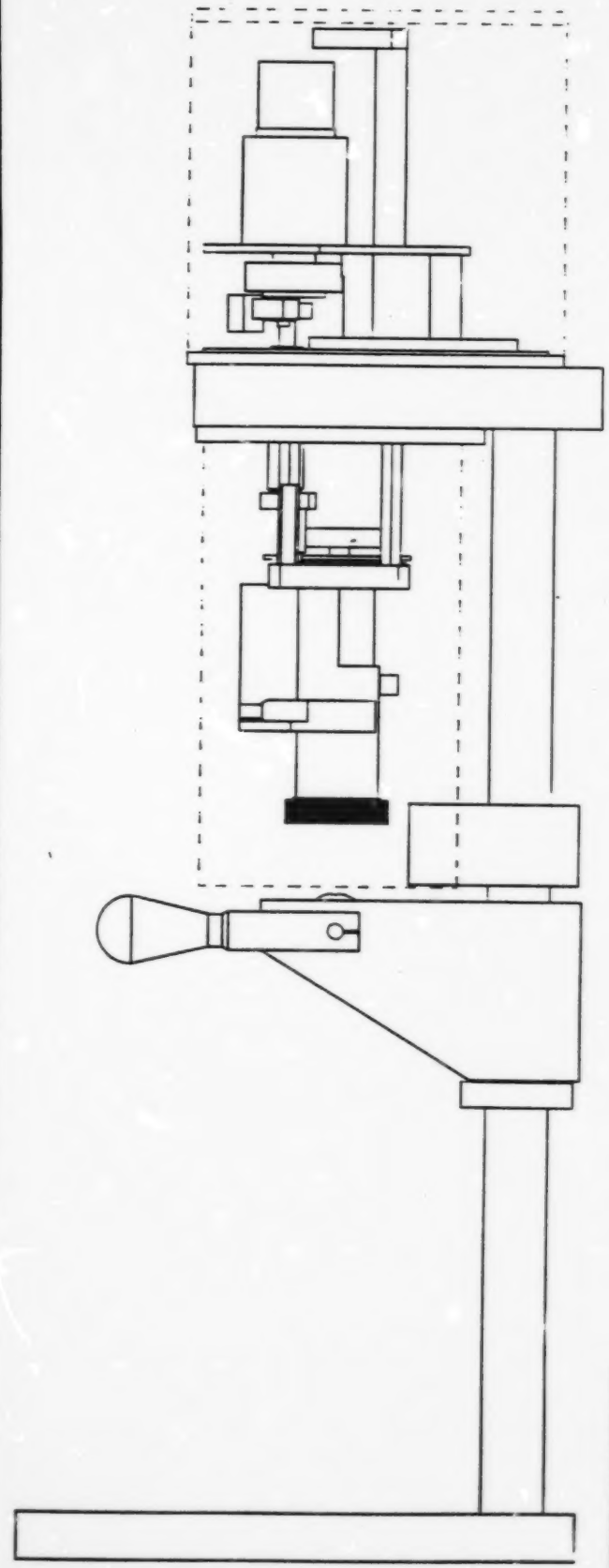


FIGURE 3

UNIVERSITY OF CALGARY DEPARTMENT OF PHYSICS		
Sample Changer Mk.I – assembly		
DR. BY *K. Szkaradzinski*		VIEW: Right
February 3, 1987	SCALE: 1:2	NO. SC–100b

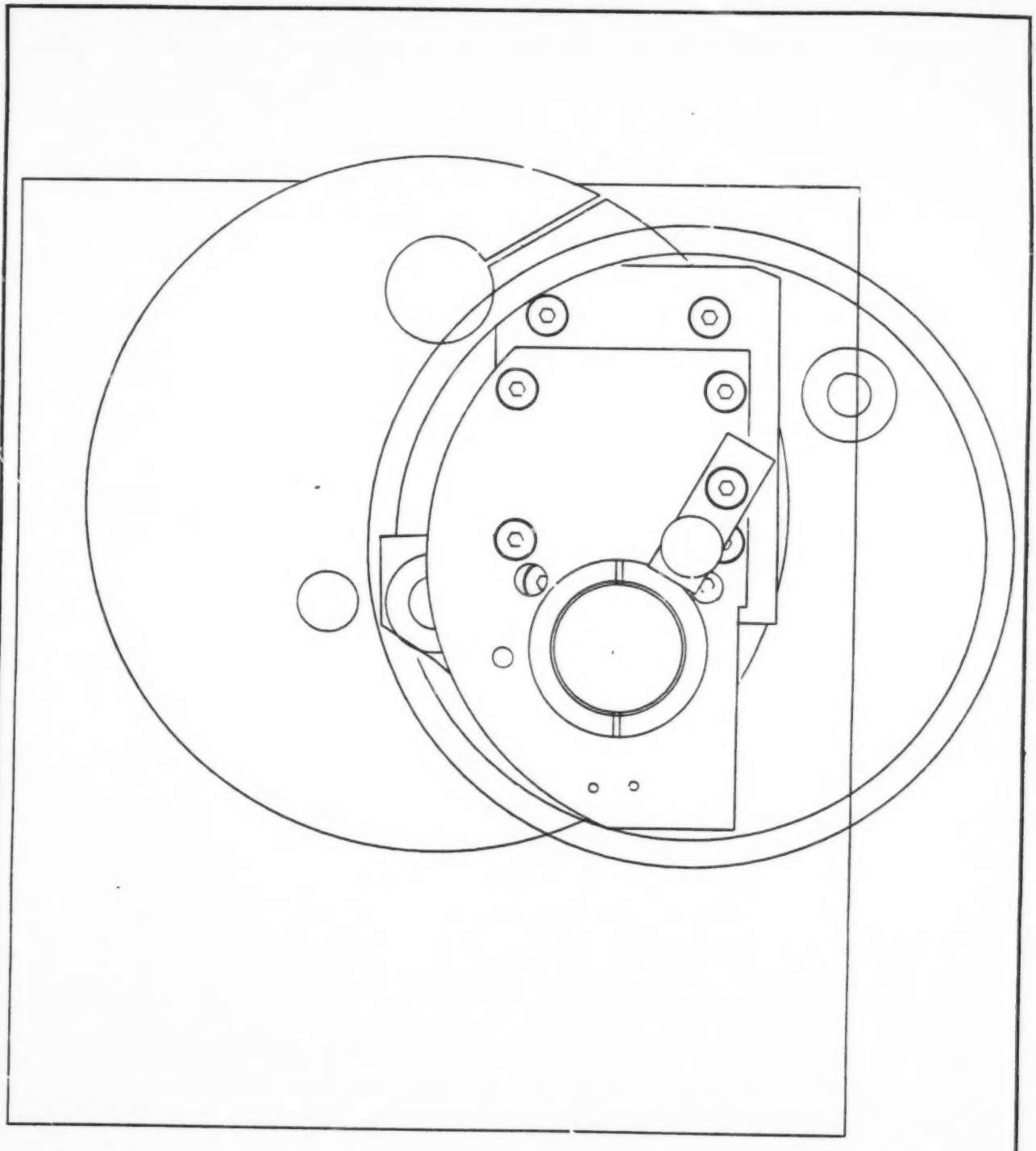


FIGURE 4

UNIVERSITY OF CALGARY DEPARTMENT OF PHYSICS		
Sample Changer Mk.I – assembly		
DR. B. K. Szkaradzinski		VIEW: Top
February 3, 1987	SCALE: 1:1	NO. SC–100c

The sample housing and the sample receiver are both cylindrical. The sample housing is directly below the alpha particle detector. Samples to be analysed are individually placed into a plastic recessed sample holder. They are then stacked and loaded into the sample housing.

The samples are pushed upward by a spring. When the top sample is removed by the changing mechanism, the one underneath automatically takes its place. The removal of the top sample involves a simple linear transverse motion through a slot and it falls into the sample receiver. The receiver is attached to the sample housing and the latter can be removed from the vacuum chamber easily for sample loading and unloading.

2. Controller/Data Acquisition Unit

This unit, as shown in Figure 1, consists of an Apple IIe computer, monitor, dual disk drive, dual paddle, and printer. Four additional computer interface cards have been added to the Apple IIe. They are printer interface, serial output interface, disc drive and 1024 multichannel analyser.

A MONENCO MASTERCARD has been developed. This software, in conjunction with the 1024 MCA card, enables the Apple IIe to function as a 1024 multichannel analyzer. It also enables the Apple IIe to control the sample changer to transfer data to the printer, to the disk drive or to an IBM computer.

A MONENCO INITCARD has also been developed. This software is needed to initialize all floppy-disks to enable them to store information generated by the Apple IIe computer.

3. System Operation

The major operation of the system is the automatic unattended analysis of alpha particle samples. The automatic analysis involves the following sequence:

a) Analysis of a sample for a length of time which is pre-determined by either x seconds or y counts accumulated in the region of interest. The maximum time per sample is 65,000 seconds.

b) Transfer pertinent data (Figure 5) to printer. This includes the sample number, the elapsed time and the number of counts in the region of interest.

c) Store all counting information in the storage disk.

d) Signal the sample changer to change to the next sample.

e) Re-set the MCA and start analysis of the next sample.

The analysis information stored on the storage disk(s) can be examined in one of the following four ways:

a) Load the spectrum onto the monitor showing the elapsed time, ROI counts and sample number. Other ROI can be examined by using cursors.

b) Transfer the spectrum to the printer to give hard copy for record keeping (Figure 6).

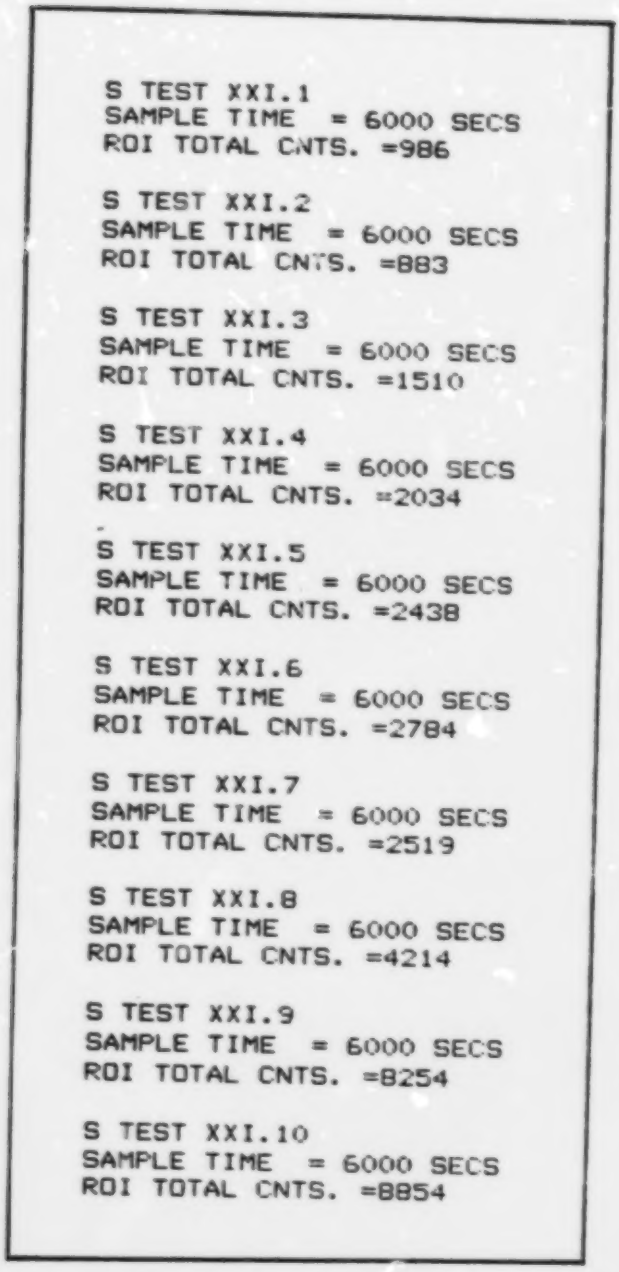

S TEST XXI.1
SAMPLE TIME = 6000 SECS
ROI TOTAL CNTS. =986
S TEST XXI.2
SAMPLE TIME = 6000 SECS
ROI TOTAL CNTS. =883
S TEST XXI.3
SAMPLE TIME = 6000 SECS
ROI TOTAL CNTS. =1510
S TEST XXI.4
SAMPLE TIME = 6000 SECS
ROI TOTAL CNTS. =2034
S TEST XXI.5
SAMPLE TIME = 6000 SECS
ROI TOTAL CNTS. =2438
S TEST XXI.6
SAMPLE TIME = 6000 SECS
ROI TOTAL CNTS. =2784
S TEST XXI.7
SAMPLE TIME = 6000 SECS
ROI TOTAL CNTS. =2519
S TEST XXI.8
SAMPLE TIME = 6000 SECS
ROI TOTAL CNTS. =4214
S TEST XXI.9
SAMPLE TIME = 6000 SECS
ROI TOTAL CNTS. =8254
S TEST XXI.10
SAMPLE TIME = 6000 SECS
ROI TOTAL CNTS. =8854

FIGURE 5

STANDARD 701-10

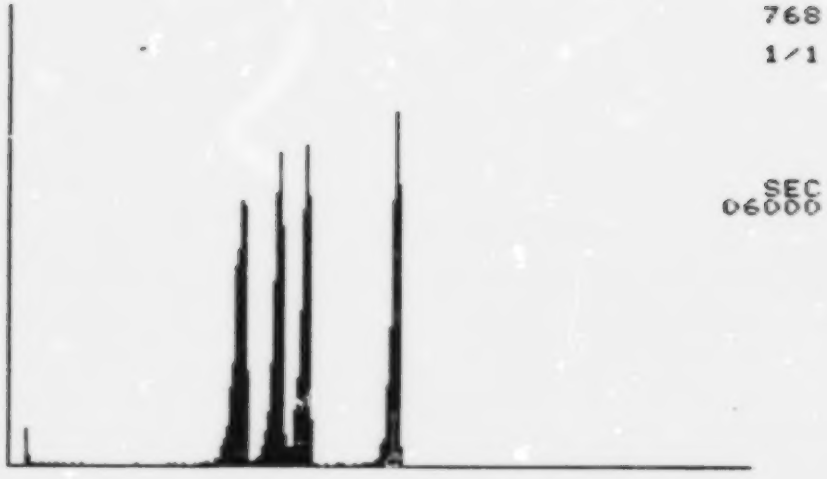


FIGURE 6

c) Transfer ROI detail to the printer to give hard copy for record keeping (Figure 7). This shows the number of counts for each individual channel.
d) Transfer ROI detail to an IBM computer (Figure 8).

C. TESTING

1. Mechanical Operation

When the changer mechanism is activated, either by computer control or by manual control, it removes the top sample which falls into the sample receiver. At the same time, the sample beneath is pushed up by the spring. This entire process takes less than two seconds, and was tested a total of eighty (80) times. Each test involved the stacking of ten (10) samples in the sample housing, and removing them one at a time to the sample receiver. Thirty (30) of these tests were activated by the manual control and fifty (50) of these tests were activated by computer control. The results of these tests indicated that:

a) The changing mechanism, ie: the linear transverse motion, functioned smoothly and never failed. It would stop only if the path for the sample being removed was blocked.

b) The sample underneath the one being removed always took its place.

256 -	4	3	6	7	3
261 -	5	4	2	5	4
266 -	10	9	5	6	6
271 -	10	8	9	6	5
276 -	5	8	12	9	4
281 -	6	8	10	14	17
286 -	17	17	12	15	28
291 -	16	32	35	39	36
296 -	47	59	40	60	65
301 -	78	91	104	128	131
306 -	133	156	170	194	243
311 -	254	328	325	384	373
316 -	356	366	443	429	440
321 -	444	417	436	434	427
326 -	364	250	159	72	25
331 -	10	11	9	7	14
336 -	10	14	12	18	15
341 -	22	24	23	17	27
346 -	19	31	32	32	39
351 -	49	59	54	60	60
356 -	88	87	125	157	169
361 -	196	226	276	305	329
366 -	387	441	455	503	512
371 -	516	523	519	544	490
376 -	396	291	203	92	52
381 -	28	18	25	35	22
386 -	40	41	35	47	55
391 -	49	92	97	88	113
396 -	146	174	205	218	258
401 -	326	386	413	425	444
406 -	534	525	535	548	552
411 -	504	451	375	259	172
416 -	76	38	4	2	4
421 -	2	1	1	4	1
426 -	3	3	1	3	2
431 -	4	1	4	1	0
436 -	4	2	1	0	1
441 -	0	1	0	0	1
446 -	2	0	2	0	0
451 -	2	4	4	4	0
456 -	5	2	5	3	4
461 -	8	6	2	3	4
466 -	4	3	2	1	3
471 -	0	1	4	3	0
476 -	4	3	1	3	3
481 -	1	0	3	2	5
486 -	2	6	5	2	2
491 -	5	7	6	6	3
496 -	4	5	5	7	7
501 -	8	12	18	11	20
506 -	10	15	15	24	32
511 -	28	37	39	38	55
516 -	47	62	70	109	135
521 -	148	188	224	229	326
526 -	361	418	441	532	564
531 -	570	588	643	598	563
536 -	469	376	217	102	33
541 -	14	3	0	0	1
546 -	1	2	0		

FIGURE 7

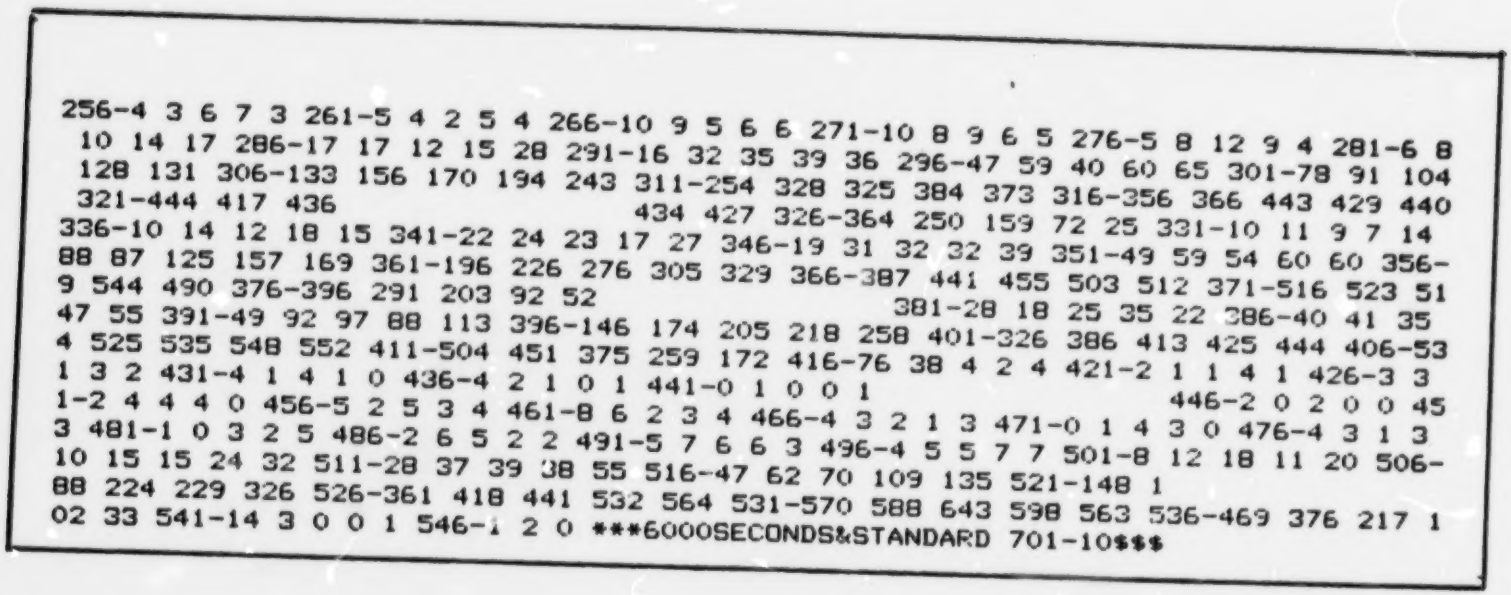

256-4 3 6 7 3 261-5 4 2 5 4 266-10 9 5 6 6 271-10 8 9 6 5 276-5 8 12 9 4 281-6 8
10 14 17 286-17 17 12 15 28 291-16 32 35 39 36 296-47 59 40 60 65 301-78 91 104
128 131 306-133 156 170 194 243 311-254 328 325 384 373 316-356 366 443 429 440
321-444 417 436 434 427 326-364 250 159 72 25 331-10 11 9 7 14
336-10 14 12 18 15 341-22 24 23 17 27 346-19 31 32 32 39 351-49 59 54 60 60 356-
88 87 125 157 169 361-196 226 276 305 329 366-387 441 455 503 512 371-516 523 51
9 544 490 376-396 291 203 92 52 381-28 18 25 35 22 386-40 41 35
47 55 391-49 92 97 88 113 396-146 174 205 218 258 401-326 386 413 425 444 406-53
4 525 535 548 552 411-504 451 375 259 172 416-76 38 4 2 4 421-2 1 1 4 1 426-3 3
1 3 2 431-4 1 4 1 0 436-4 2 1 0 1 441-0 1 0 0 1 446-2 0 2 0 0 45
1-2 4 4 4 0 456-5 2 5 3 4 461-8 6 2 3 4 466-4 3 2 1 3 471-0 1 4 3 0 476-4 3 1 3
3 481-1 0 3 2 5 486-2 6 5 2 2 491-5 7 6 6 3 496-4 5 5 7 7 501-8 12 18 11 20 506-
10 15 15 24 32 511-28 37 39 38 55 516-47 62 70 109 135 521-148 1
88 224 229 326 526-361 418 441 532 564 531-570 588 643 598 563 536-469 376 217 1
02 33 541-14 3 0 0 1 546-1 2 0 ***6000SECONDS&STANDARD 701-10$$$

FIGURE 8

c) The samples being removed, ideally should fall into the cylindrical receiver right side up and on top of each other. However, these tests showed that the first three (3) samples had a ten percent (10%) chance of flipping over during the fall. Samples 3, 4 and 5 had a ten percent (10%) chance of landing on an angle. The flipping over had no effect on the changing mechanism, however, when one sample was landed on an angle, it caused the succeeding to land on an angle. This caused them to take up more vertical space in the sample receiver and when it was fully occupied, it blocked the path of the next sample being removed. This caused the changing mechanism to stop.

2. Complete System Operation

Ten (10) Ra-226 samples were prepared and analysed to test the operational characteristics of the complete system. They were tested ten (10) times by the "Time" mode. All ten (10) samples were loaded into the sample housing in numerical order in each test. The first test started with sample 1, the second test started with sample 2 and so on. Similarly, they were tested ten (10) more times by the "ROI" mode. Therefore, each sample was analysed twenty (20) times, 10 by time and 10 by ROI, and each sample occupied each of the ten (10) loading positions of the sample housing twice.

The mechanical results were discussed in Section C.1 above. The controller/data acquisition unit functioned as discussed in Section B.3 above. That is to say, it analysed a sample, transferred pertinent data to the printer, stored all counting information on the disk, activated the sample changer to change to a new sample, re-set the MCA, and started to analyse the next sample.

Tables 1 and 2 summarized the analytical results for Standard 701-1 to 701-10. It can be seen that:

a) Random loading of the samples has no effect on the analytical results,
b) Flipping over did not cause any cross-contamination, and
c) Analysis by pre-setting time or ROI gave essentially the same results.

D. OPERATION INSTRUCTION

1. Sample Changer

a) Turn off vacuum pump and release vacuum
b) Release vacuum chamber support and swing it to the right
c) Carefully lower vacuum chamber to expose the sample housing/receiver assembly
d) Carefully remove sample housing/reveiver assembly by sliding it forward and place it on the countertop.
e) To load samples into the sample housing, lower the piston and swing to the left to the lock position. Insert samples and carefully raise the piston to push samples to the top.
f) To remove samples from the sample receiver, remove the receiver from the assembly and slide samples out the top of the receiver. Insert the receiver back to the assembly.
g) Replace the sample housing/receiver assembly, then the vacuum chamber and the support
h) Apply vacuum
i) Slowly increase bias voltage to detector.

COUNTS PER MINUTE BY TIME

	6500 Sec.	900 Sec.	1800 Sec.	6500 Sec.	1800 Sec.	6500 Sec.	6000 Sec.	1200 Sec.	2400 Sec.	1200 Sec.	MEAN	S.D.
701-1	9.4±0.3		9.9±0.6	9.6±0.3	10.0±0.6	9.4±0.3	9.5±0.3	9.6±0.7	9.9±0.5	10.3±0.7	9.7	0.3
701-2	9.2±0.3	8.6±0.8	8.3±0.5	8.4±0.3		9.2±0.3	9.6±0.3	8.7±0.7	9.5±0.5	8.6 ±0.7	8.9	0.5
701-3	15.1±0.4	14.5±1.0	14.9±0.7	14.2±0.4	14.0±0.7	15.5±0.4	15.3±0.4	15.3±0.9	15.0±0.6	14.4±0.8	14.8	0.5
701-4	19.5±0.4	20.9±1.2	21.2±0.8	20.4±0.4	20.8±0.8	20.0±0.4	21.2±0.5		21.2±0.7	21.1±1.0	20.7	0.6
701-5	22.7±0.5	24.5±1.3	23.6±0.9	24.2±0.5	24.4±0.9	24.5±0.5	23.4±0.5		23.3±0.8	24.1±1.1	23.9	0.6
701-6	27.2±0.5	28.9±1.4	29.0±1.0	28.1±0.5	27.5±1.0	28.3±0.5	27.4±0.5		28.2±0.8	27.4±1.2	28.0	0.7
701-7	24.0±0.5	23.7±1.3	23.7±0.9	25.0±0.5	25.3±0.9	24.7±0.5	24.6±0.5	26.4±1.2		25.3±1.1	24.7	0.9
701-8	40.6±0.6	40.0±1.6	42.3±1.2	42.4±0.6	45.2±1.2	41.6±0.6	41.9±0.6	41.2±1.4	42.4±1.0	44.1±1.5	42.2	1.7
701-9	80.9±0.9		84.2±1.7	82.9±0.9	84.1±1.7	83.2±0.9	84.0±0.9	84.6±2.1	84.4±1.5	77.5±2.0	82.9	2.3
701-10	92.3±0.9		94.5±1.8	96.1±0.9	96.2±1.8	94.2±0.9	98.0±1.0	91.0±2.1	92.2±1.5	92.5±2.2	94.1	2.3

TABLE 1

COUNTS PER MINUTE BY REGION OF INTEREST

	200 Cts.	200 Cts.	2000 Cts.	500 Cts.	2000 Cts.	500 Cts.	500 Cts.	2500 Cts.	500 Cts.	Cts.	MEAN	S.D.
701-1	10.7±0.8		9.9±0.2	9.6±0.4	9.9±0.2	9.7±0.4	10.1±0.5	9.8±0.2	9.6±0.4	9.7±0.4	9.9	0.3
701-2	10.4±0.7	10.1±0.7	9.3±0.2	8.7±0.4	9.0±0.2	10.1±0.5	8.6±0.4	8.9±0.2	9.3±0.4	8.6±0.4	9.3	0.7
701-3	15.8±1.1	14.4±1.0	14.2±0.3	15.2±0.7	15.7±0.4	15.0±0.7	14.6±0.7	14.5±0.3	14.8±0.7	14.4±0.7	14.9	0.6
701-4	22.8±1.5	18.9±1.3	20.8±0.5	21.7±1.0	20.4±0.5	22.4±1.0	20.3±0.9	20.1±0.4	19.6±0.9	20.3±0.9	20.7	1.2
701-5	20.7±1.5	22.4±1.6	24.0±0.5	24.5±1.1	23.8±0.5	23.2±1.0		23.4±0.5	25.9±1.2	26.9±1.2	23.9	1.8
701-6	27.5±1.9	30.1±2.1	28.0±0.6	26.1±1.2	27.3±0.6	26.4±1.2		28.5±0.6	27.0±1.2	25.5±1.1	27.4	1.4
701-7	25.7±1.8	26.5±1.9	26.0±0.6	24.7±1.1	26.0±0.6	25.9±1.2	24.5±1.1	22.5±0.5	23.9±1.1	27.4±1.2	25.3	1.4
701-8	42.9±3.0	38.8±2.7	43.3±1.0	42.8±1.9	41.2±0.9	41.6±1.9	41.2±1.8	41.8±0.8	37.6±1.7	42.8±1.9	41.4	1.9
701-9	79.3±5.6	82.0±5.8	82.6±2.0	89.2±4.0	85.3±1.9	91.6±4.1	89.7±4.0	85.1±1.7	82.1±3.7	85.9±3.8	85.3	3.9
701-10	93.5±6.6		87.7±2.0	94.2±4.2	93.7±2.1	91.9±4.1	91.9±4.1	91.0±1.8	89.0±4.0	90.5±4.0	91.5	2.2

TABLE 2

2. Controller/Data Acquisition Unit

2.1 UNIT Storage Disks

a) Insert MONENCO INITCARD to disk drive 1
b) Turn power on
c) Wait for instruction on monitor
d) Remove MONENCO INITCARD from disk drive 1
e) Insert a storage disk to disk drive 1
f) Print "INIT HELLO" and press "Return" key
g) When light on disk drive 1 goes off, remove storage disk and insert next disk.

2.2 Analysis

a) Load samples into sample changer as in Section D.1.
b) Insert MONENCO MASTERCARD to disk drive 1
c) Turn on power
d) Wait until the loading of MASTERCARD is completed (monitor shows Display) then remove it
e) Insert storage disks to both disk drive 1 and 2
f) Set ROI by pressing "R" key and move the cursors using the paddle controls
g) Press "J" key for setting analysis routine and type in the information as prompted:

- Name for samples to be analysed in ten (10) characters or less, press "Return"
- Time or ROI mode
- Number of samples to be analysed
- The start number of a sequence to become part of the name given above

- Time in sec (length of analysis, time for each sample) and press "Return"

h) Analysis can be interrupted by pressing "D" and to resume, press "D" then "K".

NOTES: (i) "J" key is entered from Display mode "D"

(ii) Make sure printer is on line.

2.3 Recall

a) Press "C" then "Return" to clear monitor.

b) Press "L" then "@" key, the monitor shows contents of storage disk

c) Type file name, press "Return" and wait for the display mode to appear on the monitor.

d) Press "X", the monitor shows the spectrum requested.

e) Press "P" and enter sample identification then press "P" to print spectrum

f) Press "R" and adjust ROI by moving the cursors using paddle controls

g) Press "P", wait, then "P" to print ROI or "I" to transfer ROI to IBM computer.

h) To identify the spectrum, press "Q" then "B", move cursor to channel 1 and read the sample number on lower right hand corner of the monitor. Press "D" then "F" to return to display

i) To inspect spectrum, use "<" and ">" or "Q", "2", "3" and "4" keys

j) To identify unknown peaks in the spectrum, press "M" and use "←", "→" and "space bar" to place cursor on the first unknown peak. Press "C", enter known energy (MeV) and press "Return". Repeat for the second known peak. Move cursor to any unknown peak and read energy value on the lower right hand corner of monitor.

E. DELIVERABLE ITEMS

Sample Changer

1 - Stand
1 - Main Assembly (Circuit Diagram - Figure 9)
1 - Removable Vacuum Chamber
1 - Removable Sample Holder
1 - Removable Sample Receiver
1 - Changer Power Supply (Circuit Diagram - Figure 10)
1 - Detector
90 - Sample Holders

Apple IIe includes:

1 - Grappler Printer Interface
1 - Nucleus 811-A Series 1024 MCA Card
1 - Serial Output Card
1 - Disc Drive Card
2 - Paddles
1 - Cable (connecting Apple IIe and IBM)

Apple DuoDisk - one
Apple II Monitor - one
Roland DG PR-1011 Printer - one

Instruction Manual

1 - Apple IIe Owner's
1 - Apple IIe Monitor II User's
1 - Apple IIe Supplement to the Apple IIe Owner's
1 - Apple IIe A Touch of Applesoft Basic
1 - Apple Duodisk Owner's
1 - Nucleus Model 811-A Series 1024 MCA Operation
1 - Grappler Printer Interface User's
1 - Roland DG PR-1011 Printer Operating
1 - Super Serial Card Installation and Operating

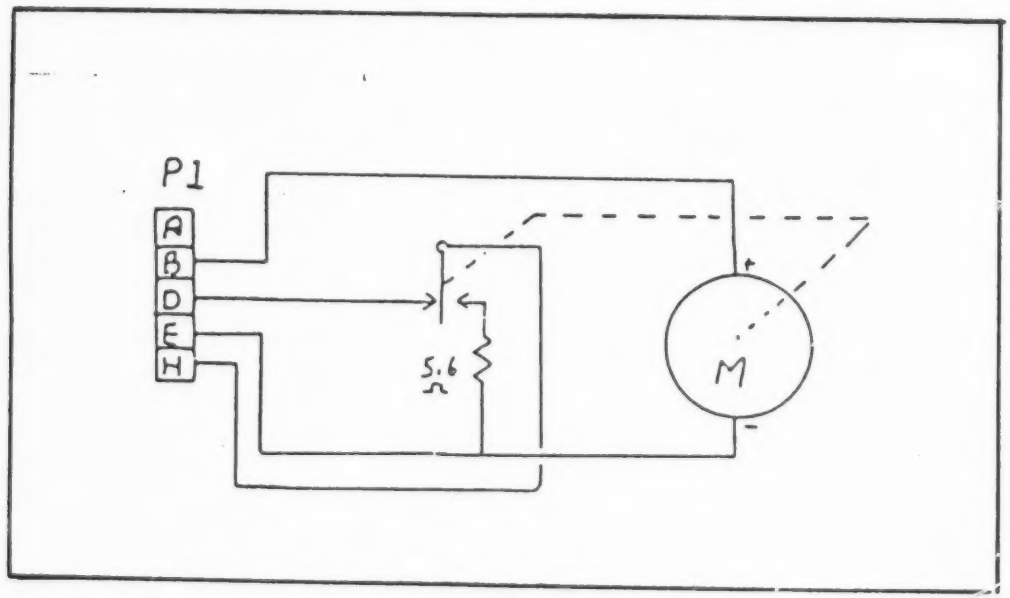
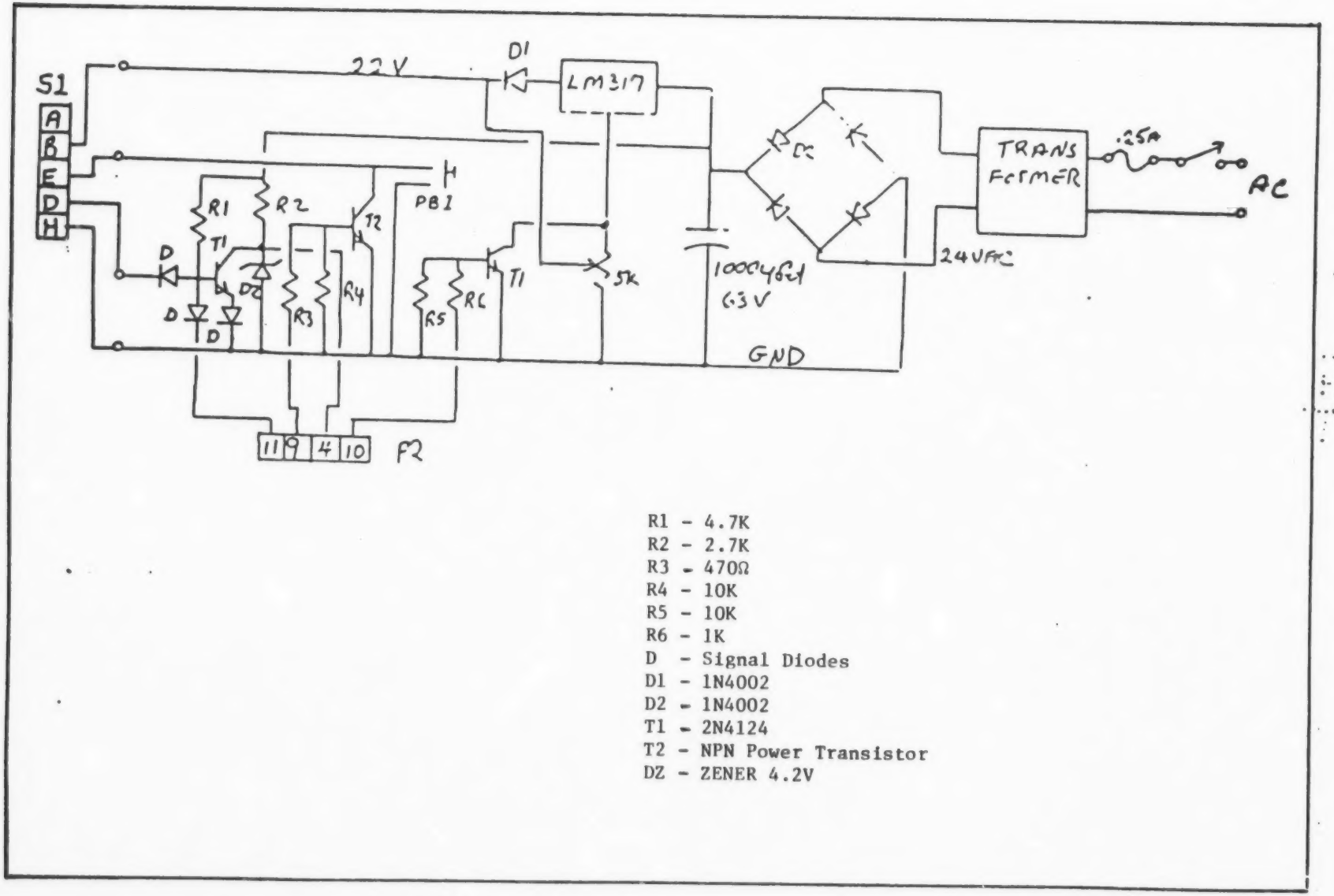


FIGURE 9 - MOTOR CIRCUIT DIAGRAM



R1 - 4.7K
R2 - 2.7K
R3 - 470Ω
R4 - 10K
R5 - 10K
R6 - 1K
D - Signal Diodes
D1 - 1N4002
D2 - 1N4002
T1 - 2N4124
T2 - NPN Power Transistor
DZ - ZENER 4.2V

FIGURE 10 - CHANGER POWER SUPPLY CIRCUIT DIAGRAM

Software

1 - MONENCO INIT Card

1 - MONENCO MASTERCARD

1 - Nucleus 811-A

1 - Apple IIe Introduction

Warranty Cards/Forms

1 - Apple Care Warranty Registration Form

1 - Apple Limited Warranty Info Card

1 - Roland DG Warranty Registration